The impurity concentration of the first conductive type layer is higher than an impurity concentration of the first column. The first column provides a drift layer so that a vertical type first-conductive-type channel transistor is formed.

[0013] In the above method, since the substrate having the first conductive type provides the first column, it is not necessary to form the first column on a support substrate. Thus, a manufacturing time and a manufacturing cost are reduced. Further, since the step of increasing the impurity concentration of the first conductive type layer is performed after the step of forming the second conductive type semiconductor film in each trench, diffusion from the substrate to the second conductive type semiconductor film is reduced. Thus, the impurity concentration in the second conductive type semiconductor film is sufficiently controlled to be a predetermined value.

[0014] According to a second aspect of the present disclosure, a method for manufacturing a semiconductor device includes: forming a plurality of trenches on a first side of a semiconductor substrate, wherein the substrate has a first conductive type; forming a second conductive type semiconductor film in each trench so that the substrate between two trenches provides a first column, and the second conductive type semiconductor film in each trench provides a second column, wherein the first and second columns are alternately repeated along with a predetermined direction in parallel to the first side of the substrate; thinning a second side of the substrate, the second side being opposite to the first side; increasing an impurity concentration of a first part of a thinned second side of the substrate so that the first part provides a first conductive type layer; and reforming a second part of the thinned second side of the substrate so that the second part provides a second conductive type layer. The first part of the thinned second side is adjacent to the second part of the thinned second side. The impurity concentration of the first conductive type layer is higher than an impurity concentration of the first column. The impurity concentration of the second conductive type layer is higher than an impurity concentration of the second column. The first column on the first part of the thinned second side provides a drift layer so that a vertical type first-conductive-type channel transistor is formed. The second column on the second part of the thinned second side provides a drift layer so that a vertical type second-conductive-type channel transistor is formed.

[0015] In the above method, the vertical type first-conductive-type channel transistor and the vertical type second-conductive-type channel transistor are manufacturing by preparing the substrate having the first conductive type. Thus, it is not necessary to form the first column on a support substrate, so that a manufacturing time and a manufacturing cost are reduced. Further, diffusion from the substrate to the second conductive type semiconductor film is reduced. Thus, the impurity concentration in the second conductive type semiconductor film is sufficiently controlled to be a predetermined value.

[0016] According to a third aspect of the present disclosure, a method for manufacturing a semiconductor device includes: forming a plurality of trenches on a first side of a semiconductor substrate, wherein the substrate has a first conductive type; forming a second conductive type semiconductor film on an inner wall of each trench by an epitaxial growth method in such a manner that a thickness of the second conductive film is equal to or smaller than a half of a width of the trench; forming an oxide film on the second conductive type semiconductor film in each trench so that the trench is filled with the oxide film, wherein the substrate between two trenches provides a first column, and the second conductive type semiconductor film in each trench provides a second column, and wherein the first and second columns are alternately repeated along with a predetermined direction in parallel to the first side of the substrate; thinning a second side of the substrate, the second side being opposite to the first side; and increasing an impurity concentration of a thinned second side of the substrate so that a first conductive type layer is provided. An impurity concentration of the first conductive type layer is higher than an impurity concentration of the first column, and the first column provides a drift layer so that a vertical type first-conductive-type channel transistor is formed.

[0017] In the above method, the width of the second conductive type semiconductor film in each trench becomes smaller, so that an on-state resistance related to the second conductive type semiconductor film is reduced. Further, a manufacturing time and a manufacturing cost are reduced. Furthermore, the impurity concentration in the second conductive type semiconductor film is sufficiently controlled to be a predetermined value.

[0018] According to a fourth aspect of the present disclosure, a method for manufacturing a semiconductor device includes: forming a plurality of trenches on a first side of a semiconductor substrate, wherein the substrate has a first conductive type; forming a second conductive type semiconductor region on an inner wall of each trench by diffusing atoms in vapor phase or implanting ions into the inner wall of the trench; forming an oxide film on the second conductive type semiconductor region in each trench so that the trench is filled with the oxide film, wherein the substrate between two trenches provides a first column, and the second conductive type semiconductor region in each trench provides a second column, wherein the first and second columns are alternately repeated along with a predetermined direction in parallel to the first side of the substrate; thinning a second side of the substrate, the second side being opposite to the first side; and increasing an impurity concentration of a thinned second side of the substrate so that a first conductive type layer is provided. An impurity concentration of the first conductive type layer is higher than an impurity concentration of the first column, and the first column provides a drift layer so that a vertical type first-conductive-type channel transistor is formed.

[0019] In the above method, a manufacturing time and a manufacturing cost are reduced, and the impurity concentration in the second conductive type semiconductor region is sufficiently controlled to be a predetermined value.

[0020] According to a fifth aspect of the present disclosure, a method for manufacturing a semiconductor device includes: forming a plurality of trenches on a first side of a semiconductor substrate, wherein the substrate has a first conductive type; forming a first conductive type semiconductor region on an inner wall of each trench by diffusing atoms in vapor phase or implanting ions into the inner wall of the trench, wherein an impurity concentration of the first conductive type semiconductor region is higher than an impurity concentration of the substrate, and wherein the substrate between the first conductive type semiconductor region in adjacent two trenches and the first conductive type semiconductor region in the adjacent two trenches provide a